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REMARKS

Prior to this Amendment, claims 1-45 are pending in the application. In the pending Office action, the Office rejected claims 1-26 and withdrew claims 27-45. In this Amendment, Applicants are canceling claims 1-15, 17-19, 21, and 23-45; amending claims 16, 20, and 22; and adding claims 46-74.

Applicants cancelled claims 1-15, 17-19, 21, and 23-26, thereby rendering any rejection of those claims as being moot.

Please note that Applicants are going to comment on the pending claims out of sequential order. Claim 46 was added by this Amendment and is repeated below for the Examiner's reference.

46. An electrical machine comprising:
a shaft rotatable about an axis;
a stator including a stator core and windings;
a rotor coupled to the shaft and adapted to interact with the stator, the rotor including a center cross-section and one or more permanent magnets configured to form at least four axial sections, each of the four axial sections having a magnetization pattern of alternating magnetic poles that are skewed with respect to the axis along substantially straight lines and having an arc of magnetization skew that is substantially the same as the other axial sections, the at least four axial sections including
a first axial section having a first magnetization direction and a first axial length,
a second axial section disposed adjacent to the first axial section, the second axial section having a second magnetization direction, having a second axial length that is substantially the same as the first axial length, and being symmetric to the first axial section with respect to the center cross-section,
a third axial section disposed adjacent to the first axial section, the third axial section having a third magnetization direction that is different than the first magnetization direction and having a third axial length, and
a fourth axial section disposed adjacent to the second axial section, the fourth axial section having a fourth magnetization direction that is different than the third magnetization direction, having a fourth axial length that is substantially the same as the third axial length, and being symmetric to the third axial section with respect to the center cross-section; and
wherein the first, second, third, and fourth magnetization directions define a continuous zig-zag pattern in the axial direction.

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Claims 1-26 were rejected as being anticipated by or obvious in view of U.S. Patent Nos. 5,034,642 (Hoemann); 6,384,503 (Iwaki); or 6,707,209 (Crapo). Applicants will address claim 46 as if the Hoemann, Iwaki, and Crapo references were cited against claim 46.

The Hoemann reference is directed to a permanent magnet rotor and motor. The Hoemann reference does not teach or suggest, among other things, a rotor including a center cross-section and one or more permanent magnets configured to form at least four axial sections, each of the four axial sections having a magnetization pattern of alternating magnetic poles that are skewed with respect to the axis along substantially straight lines and having an arc of magnetization skew that is substantially the same as the other axial sections. Before proceeding further, it is noted that the arc of magnetization skew has a clear meaning within the application. See, e.g., the Application p. 6, lines 1-4 and Fig. 13. The Hoemann reference, on the other hand, describe a rotor having longitudinally extending strips of alternating magnetic polarity that are skewed in a predetermined pattern.

> The predetermined pattern includes a first portion in which each longitudinally extending strip runs generally at a first predetermined non-zero angle with respect to the longitudinal axis of the rotor, a second portion in which each longitudinally extending strip runs generally at a second predetermined non-zero angle with respect to the longitudinal axis of the rotor, and a third portion in which each longitudinally extending strip runs generally at the first predetermined non-zero angle with respect to the longitudinal axis of the rotor. Abstract.

Additionally, the three portions of the Hoemann reference meet set geometrical relationships. See col. 4, lines 14-58.

Therefore, the Hoemann reference explicitly defines the rotor as including three axial sections (the claim 46 requires at least four) having a magnetization pattern of alternating magnetic poles, and consequently, teaches away from the claimed invention. Even more important, the Hoemann reference does not teach or suggest that the three axial sections have the same arc of magnetization skew as required by claim 46. This is best shown in Figs. 8 and 10 of the Hoemann reference, which is attached as Exhibit 1. With reference to Fig. 8, axial section 27 has an arc of magnetization skew β. Axial sections 25 and 29 are explicitly defined by the Hoemann reference as being less than β. See col. 4, lines 42-58. For example, at neutral

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position (which is shown in Figs. 8 and 10), sections 25 and 29 have an arc of magnetization skew of $\beta/2$. Therefore, the Hoemann reference does not teach or suggest claim 46.

Before addressing obviousness, it should be noted that it is impossible for axial section 25 to be symmetric to axial section 29 with respect to the center cross-section of the rotor, as required by claim 46, because of the geometrical relationships taught by the Hoemann reference.

Claim 46 is not obvious in view of the Hoemann reference because the Hoemann reference explicitly teaches away from claim 46 by requiring the rotor to satisfy the geometrical relationships established at col. 4, lines 14-55. Specifically, the Hoemann rotor, explicitly requires three sections and the three sections cannot have the same arc of magnetization skew. Furthermore, while the Hoemann reference may address issues with cogging torque, the Hoemann reference does not address ripple torque and side-pull like Applicants invention. Accordingly, claim 46 is not obvious in view of the Hoemann reference.

The Iwaki reference is directed to a motor having a rotor with permanent magnets magnetized so that a boundary between each pair of skewed magnetic poles is generally S-shaped. See, e.g., Fig. 7. The Iwaki reference does not teach or suggest, among other things, a rotor including a center cross-section and one or more permanent magnets configured to form at least four axial sections, each of the four axial sections having a magnetization pattern of alternating magnetic poles that are skewed with respect to the axis along substantially straight lines and having an arc of magnetization skew that is substantially the same as the other axial sections, where the first, second, third, and fourth magnetization directions define a continuous zig-zag pattern in the axial direction. Additionally, it is impossible for axial section 62a (Fig. 7) to be symmetric to axial section 62c with respect to the center cross-section of the rotor, as required by claim 46, because of the generally S-shaped skew of the magnets. Therefore, the Iwaki reference does not teach or suggest claim 46.

Claim 46 is not obvious in view of the Iwaki reference because the Iwaki reference teaches away from a zig-zag pattern, as recited in claim 46, by explicitly teaching that the permanent magnets are to be magnetized so that a boundary between each pair of skewed magnetic poles is generally S-shaped. Accordingly, claim 46 is not obvious in view of the Iwaki reference.

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The Crapo reference is directed to a permanent magnet electric machine with reduced cogging torque having a plurality of axial rotor sections rotationally offset such that the edges of permanent magnets create stair step interfaces. See, e.g., Fig. 7. The Crapo reference does not teach or suggest, among other things, a rotor including a center cross-section and one or more permanent magnets configured to form at least four axial sections, each of the four axial sections having a magnetization pattern of alternating magnetic poles that are skewed with respect to the axis along substantially straight lines and having an arc of magnetization skew that is substantially the same as the other axial sections, where the first, second, third, and fourth magnetization directions define a continuous zig-zag pattern in the axial direction. Additionally, it is impossible for axial section 220 to be symmetric to axial section 226 with respect to the center cross-section of the rotor, as required by claim 46, because of the stair step interfaces. Therefore, the Crapo reference does not teach or suggest claim 46.

Claim 46 is not obvious in view of the Crapo reference because the Crapo reference teaches away from a zig-zag pattern, as recited in claim 46, by explicitly teaching that the plurality of axial rotor sections are rotationally offset such that the edges of permanent magnets create stair step interfaces. Accordingly, claim 46 is not obvious in view of the Iwaki reference.

Consequently, claim 46 is patentable, and Applicants request indication of the same. Claims 47-53 depend, either directly or indirectly, from claim 46, and consequently, include patentable subject matter for the reasons set forth above with respect to claim 46. Therefore, dependent claims 47-53 are allowable. Additionally, claims 47-53 specify additional elements and/or limitations that, in combination with claim 46, are believed to be inventive.

Claim 54 was added by this Amendment and is repeated below for the Examiner's reference.

54. An electrical machine comprising:
a shaft rotatable about an axis;
a stator including a stator core and windings;
a rotor coupled to the shaft and adapted to interact with the stator, the rotor including a center cross-section and one or more permanent magnets configured to form at least three axial sections, each of the three axial sections having a magnetization pattern of alternating magnetic poles that are skewed with respect to the axis along substantially straight lines and having an arc of magnetization

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skew that is substantially the same as the other axial sections, the at least three axial sections including

a first axial section having a first magnetization direction and a first axial length, the center cross-section of the first axial section being the same as the center cross-section of the rotor,

a second axial section disposed adjacent to the first axial section, the second axial section having a second magnetization direction that is different than the first magnetization direction and having a second axial length, and

a third axial section disposed adjacent to the first axial section, the third axial section having a third magnetization direction that is different than the first magnetization direction, having a third axial length that is substantially the same as the second axial length, and being symmetric to the second axial section with respect to the center cross-section; and

wherein the first, second, and third magnetization directions define a continuous zig-zag pattern in the axial direction.

Applicants will address claim 54 as if the Hoemann, Iwaki, and Crapo references were cited against claim 54.

Not one of the Hoemann, Iwaki, or Crapo references teach or suggest, among other things, a rotor including a center cross-section and one or more permanent magnets configured to form at least three axial sections, each of the three axial sections having a magnetization pattern of alternating magnetic poles that are skewed with respect to the axis along substantially straight lines and having an arc of magnetization skew that is substantially the same as the other axial sections, where the first, second, and third magnetization directions define a continuous zig-zag pattern in the axial direction. In addition, not one of the Hoemann, Iwaki, or Crapo references teach or suggest that the third axial section is symmetric to the second axial section with respect to the center cross-section. Rather, and as discussed earlier, the Hoemann reference requires the axial sections of the rotor to satisfy explicitly set geometrical relationships, where the outer axial sections of the rotor have an arc of magnetization skew less than the middle axial section, and where the axial sections are not symmetric with respect to the center cross-section of the rotor. The Iwaki reference is directed to a motor having a rotor with permanent magnets magnetized so that a boundary between each pair of skewed magnetic poles is generally S-shaped. The Crapo reference is directed to a permanent magnet electric machine with reduced cogging torque having a plurality of axial rotor sections rotationally offset such that the edges of permanent magnets create stair step interfaces. In addition, each of the cited references have explicit

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teachings that teach away from claim 54. Accordingly, claim 54 is patentable, and Applicants request indication of the same.

Claims 55-60 depend, either directly or indirectly, from claim 54, and consequently, include patentable subject matter for the reasons set forth above with respect to claim 54. Therefore, dependent claims 55-60 are allowable. Additionally, claims 55-60 specify additional elements and/or limitations that, in combination with claim 54, are believed to be inventive.

Claim 16 stands rejected as being unpatentable in view of the Hoemann, Iwaki, and Crapo references. Claim 16 is repeated below for the Examiner's reference.

> 16. An electrical machine having an output rating (P_x), the electrical machine comprising:
>
> a shaft rotatable about an axis;
>
> a stator including a stator core and windings, the stator core having a fixed cross-sectional profile with respect to the axis; and
>
> a rotor coupled to the shaft and adapted to magnetically interact with the stator, the rotor having a periphery, the rotor being configured to include three or more axial sections, each of the axial sections having a respective magnetization pattern of alternating magnetic poles skewed with respect to the axis, the magnetization pattern for each of the axial sections being different than any adjacent axial section, the three or more axial sections defining a total length (L_x) in the axial direction with respect to the axis,
>
> where (L_x) satisfies the relationship ($0.75\ (P_x/P_m) \leq (L_x/L_m) \leq 1.5\ (P_x/P_m)$),
>
> where (P_m) is a chosen maximum output rating for an electrical machine built with a stator core having the fixed cross-sectional profile,
>
> where (L_m) is the length corresponding to the length of the rotor for the maximum output rating (P_m),
>
> where (P_x) is less than the maximum output rating (P_m), and
>
> where each of the axial sections define an arc of skew (β) at the periphery, (β) being the same for each of the axial sections.

Not one of the Hoemann, Iwaki, or Crapo references teach or suggest, among other things, a rotor being configured to include three or more axial sections, each of the axial sections having a respective magnetization pattern of alternating magnetic poles skewed with respect to the axis, the magnetization pattern for each of the axial sections being different than any adjacent axial section, where each of the axial sections define an arc of skew (β) at the periphery, (β) being the same for each of the axial sections. Rather, and as discussed earlier, the Hoemann

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reference requires the axial sections of the rotor to satisfy explicitly set geometrical relationships, where the outer axial sections of the rotor have an arc of magnetization skew less than the middle axial section. The Iwaki reference is directed to a motor having a rotor with permanent magnets magnetized so that a boundary between each pair of skewed magnetic poles is generally S-shaped. The Crapo reference is directed to a permanent magnet electric machine with reduced cogging torque having a plurality of axial rotor sections rotationally offset such that the edges of permanent magnets create stair step interfaces. In addition, each of the cited references have explicit teachings that teach away from claim 16. Accordingly, claim 16 is patentable, and Applicants request indication of the same.

Claims 20 and 22 depend from claim 16, and consequently, include patentable subject matter for the reasons set forth above with respect to claim 16. Therefore, dependent claims 20 and 22 are allowable. Additionally, claims 20 and 22 specify additional elements and/or limitations that, in combination with claim 16, are believed to be inventive.

Claims 61 and 68 are directed to a family of electrical machines. For claim 61, the first electrical machine comprises, among other things, a first stator core having a cross-sectional profile and a first rotor having a first axial section and a second axial section. The first axial section has a first magnetization direction and a first axial length; and the second axial section is disposed adjacent to the first axial section, has a second magnetization direction, has a second axial length that is substantially the same as the first axial length, and is symmetric to the first axial section with respect to the first center cross-section. The second electrical machine comprises, among other things, a second stator core having the cross-sectional profile and a second rotor having third, fourth, fifth, and sixth axial sections. The third axial section has the first magnetization direction and the first axial length; the fourth axial section is disposed adjacent to the third axial section, has the second magnetization direction, has the second axial length, and is symmetric to the third axial section with respect to the second center cross-section; the fifth axial section is disposed adjacent to the third axial section, has a third magnetization direction that is different than the first magnetization direction and has a third axial length; and the sixth axial section is disposed adjacent to the fourth axial section, has a fourth magnetization direction that is different than the second magnetization direction, has a fourth axial length that is substantially the same as the third axial length, and is symmetric to the fifth axial section with

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respect to the second center cross-section. Claim 61 further recites that the first, second, third, and fourth magnetization directions define a continuous zig-zag.

For claim 68, the first electrical machine comprises, among other things, a first stator core having a cross-sectional profile and a first rotor having a first axial section. The first axial section has a magnetization pattern of alternating magnetic poles that are skewed with respect to the first axis and a first axial length, the center cross-section of the first axial section being the same as the center cross-section of the first rotor. The second electrical machine comprises, among other things, a second stator core having the cross-sectional profile and a second rotor having second, third, and fourth axial sections. The second axial section has the first magnetization direction and the first axial length, the center cross-section of the second axial section being the same as the second center cross-section of the second rotor; the third axial section is disposed adjacent to the second axial section, has a second magnetization direction that is different than the first magnetization direction and has a second axial length; the fourth axial section is disposed adjacent to the second axial section, has a third magnetization direction that is different than the first magnetization direction, has a third axial length that is substantially the same as the second axial length, and is symmetric to the third axial section with respect to the second center cross-section Claim 68 further recites that the first, second, and third magnetization directions define a continuous zig-zag.

Not one of the Hoemann, Iwaki, or Crapo references teach or suggest, among other things, the family of electrical machines of claim 61 or claim 68. The Hoemann reference requires its machines to have three axial sections, where the length of each axial section is set by geometrical relationships. That is, the Hoemann reference teaches away from adding axial sections to its machines. Additionally and as previously discussed, it is impossible for any machine following the Hoemann teachings to have outer sections that are symmetrical with respect to the center cross section of the rotor. Therefore, the Hoemann reference teaches away from claims 61 and 68. The Iwaki reference is directed to a motor having a rotor with permanent magnets magnetized so that a boundary between each pair of skewed magnetic poles is generally S-shaped. Therefore, the Iwaki reference teaches away from the zig-zig pattern of claims 61 and 68. The Crapo reference is directed to a permanent magnet electric machine with reduced cogging torque having a plurality of axial rotor sections rotationally offset such that the edges of

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permanent magnets create stair step interfaces. Therefore, the Crapo reference also teaches away from the zig-zig pattern of claims 61 and 68. Accordingly, claims 61 and 68 are patentable, and Applicants request indication of the same.

Claims 62-67 and 69-74 depend, either directly or indirectly, from one of claim 61 or claim 68, and consequently, include patentable subject matter for the reasons set forth above with respect to claim 61 or claim 68. Therefore, dependent claims 62-67 and 69-74 are allowable. Additionally, claims 62-67 and 69-74 specify additional elements and/or limitations that, in combination with one of claim 61 or claim 68, are believed to be inventive.

CONCLUSION

Entry of the Amendment and allowance of claims 16, 20, 22, and 46-74 are respectfully requested. The undersigned is available for telephone consultation at any time during normal business hours.

Respectfully submitted,

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